DOCUMENT RESUME

ED 169 866 HE 011 258

AUTHOR	Rose, Clare; And Others
TITLE	The Study of the Academic Employment and Graduate Enrollment Patterns and Trends of Women in Science and Engineering. Summary Report.
INSTITUTION	Evaluation and Training Inst., Los Angeles, Calif.
SPONS AGENCY	National Science Foundation, Washington, D.C.
PUB DATE	78
GRANT	SRS-76-82705; SRS-77-16927
NOTE	44p.
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Case Studies; Departments; Employment Patterns; *Engineering; Engineering Education; Enrollment Trends; Environmental Education; Females; Geographic Location; Graduate Study; Higher Education; *Mathematics; Mathematics Education; Medical Education; National Surveys; Private Colleges; Psychology; Science Education; *Sciences; *Social Sciences; State Universities; Statistical Studies; Trend Analysis; Universities; *Womens Education; *Working Women
IDENTIFIERS	Full Time Students; Harvard University MA; Louisiana State University Baton Rouge; Northwestern University IL; Purdue University IN; Texas A and M University; University of Arizona; University of Michigan; University of Southern California; University of Washington

ABSTRACT

A study was undertaken of the employment and enrollment patterns of women scientists/engineers and graduate students in eight major scientific fields: engineering, physical sciences, environmental sciences, mathematical sciences, agricultural and biological sciences, medical sciences, psychology, and social sciences. The first part of the study consisted of a series of statistical analyses of institutional and departmental patterns in women's full-time graduate enrollment and full-time employment in sciences and engineering in the 50 leading doctorate-granting institutions. The second phase consisted of case study site visits to a sample of nine institutions selected to represent the diversity of the original sample in geographic location, urban/rural environment, institutional size, type of control, and proportion of women scientists employed. The case study institutions were the University of Arizona, Harvard University, Louisiana State University (Baton Rouge), University of Michigan, Northwestern University, Purdue University, University of Southern California, Texas A & M University, and the University of Washington. The statistical analyses employed were designed to identify distinctive trends, to move beyond presentation of numbers and percentages to search for significant and distinctive differences. The report was exploratory and descriptive in nature, without specific research hypotheses. The analyses and results are described, with some graphic illustration. (Author/MSE)

ED169866

The Study of Women in Science and Engineering

Summary Report

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Evaluation and Training Institute

Dolores E. Noyes

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) AND USERS OF THE ERIC SYSTEM."

U S DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

NE 0 11 a 5 8

EVALUATION AND TRAINING INSTITUTE
An inter-disciplinary center for research, training, evaluation and policy studies

Los Angeles, California

THE STUDY OF THE ACADEMIC EMPLOYMENT AND GRADUATE ENROLLMENT PATTERNS AND TRENDS OF WOMEN IN SCIENCE AND ENGINEERING

Summary

Project conducted by

Clare Rose, Sally Ann Menninger and Glenn F. Nyre

Evaluation and Training Institute

1978

This material is based upon research supported by the National Science Foundation under Grant Nos. SRS76-82705 and SRS77-16927. Any opinions, findings and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the National Science Foundation.

© 1979 The Evaluation and Training Institute

All rights reserved. Except as explicitly permitted herein, no part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopy and recording, without permission in writing from the Evaluation and Training Institute.

12401 Wilshire Boulevard, Suite 304
Los Angeles, California 90025

PREFACE

This study received the American Educational Research Association and Women Educator's 1979 Research on Women in Education Award.

We are grateful to the National Science Foundation for giving us the opportunity to conduct the research and to Richard S. Berry and Penny Foster, Universities and Nonprofit Institutions Studies Group, for their continuing encouragement and support.

The Authors

INTRODUCTION

Since the late 1960s, dramatic changes have taken place in the role and status of women. Increasing numbers of women of all ages and backgrounds have entered postsecondary education, completed degrees and begun careers in a variety of fields. The overall number of women enrolling in colleges and universities has been increasing at a steady pace, and as of Fall, 1978, women comprised 49 percent of the total undergraduate enrollment in the United States.[1] Within only one decade, the number of undergraduate degrees awarded to women more than doubled, from 664,000 in 1964-65 to 1,305,000 ten years later, with women accounting for 43 percent of the baccalaureate degrees awarded in 1974-75.[2]

Changes are also taking place at the graduate level. The percentage of women receiving doctorates nationally rose from about 10 percent in 1955 to almost 13 percent in 1968, 18 percent in 1973, and an all time high of over 23 percent in 1976.[3] The number of women receiving doctorates in science and engineering rose dramatically from about 750 in 1965 (7 percent) to nearly 3,000 (17 percent) in 1976.[4]

Without question, the women's movement has heightened women's awareness of the varied alternatives and options available to them, and to a great extent has been responsible for the increasing numbers of women entering colleges and universities. In addition, affirmative action programs have provided new opportunities for careers and raised women's expectations for gainful employment when their degrees have been

completed.

Within academe, affirmative action programs have been initiated to increase women's participation at all levels -- as graduate students, as faculty, and as members of professional committees and organizations. Yet, the evidence is that while federal legislation and affirmative action may have reduced discrimination to some degree, they have not had a significant impact upon the numbers and status of women employed in colleges and universities. This is particularly true in the case of women scientists.

During the period from 1929-1940, 27 percent of the post-secondary faculty in the United States were women.[5] However, by 1975-6, only 24 percent of the 289,048 full-time faculty were women. Within the sciences, in spite of the gains in the numbers of women receiving doctorates in recent years, the proportion of women scientists employed full time in academic institutions has increased only 1 percentage point (from 15 to 16 percent) since 1974.[6]

Academic women have been found to be clustered in the lower professorial ranks and in less prestigious institutions. According to a study conducted by Ladd and Lipset in 1976, only 8 percent of women faculty are in institutions ranked as most prestigious, while 27 percent are in those ranked as least prestigious.[7] As far as job position is concerned, the proportion of women decreases with each step up the academic ladder. Women hold 41 percent of the instructor positions, 40 percent of the lectureships and 29 percent of the assistant professor positions, but only 17 percent of the associate professorships. The even

lower percentage of women holding full professorships -- 10 percent -- is the same as it was twenty years ago.[8]

Increasing numbers of part-time, off-ladder and non-tenured appointments have been made available to women, but the percentage of full-time, tenured appointments held by them has not increased significantly, and in some cases it has actually decreased. For example, women received 7 percent of the Ph.D.s in mathematics in 1974 and 13 percent in 1977; however, from 1975 to 1976, the percentage of academic women mathematicians only increased one-tenth of one percent, from 4.7 percent to 4.8 percent.[9] Women earned 20 percent of the bachelor's degrees, 22 percent of the masters and 11 percent of the Ph.D.s granted in chemistry in 1976. Yet, the American Chemical Society found that women chemists held only 2 percent of the full-time academic positions in that same year.[10]

In addition to academic rank and position, salaries are an important indicator of the status of academic women. Salary differentials between male and female academics continue to exist, and, in fact, appear to be widening. In 1974-75, faculty women earned an average of $2,820 less than faculty men;[11] in 1976-77, the differential was $3,230.[12] Women scientists are an even greater minority within academe and they fare no better than other female academics with respect to salary. In fact, women chemists earn less than men with equal levels of training, experience, and job responsibility.[13a,b&c]

Women have been active members of the scientific community for well over a century. But their numbers have been few and their status has been low; they have had few job opportunities,

frequent unemployment, and they have seldom been considered eminent by their fellow scientists. The proportion of women scientists in academe continues to be small, and it drops significantly the higher the level of degree, academic rank, salary or administrative responsibility. These facts raise serious questions about the real impact of equal opportunities for women as far as job access, position, promotion and salaries are concerned. The present study was designed to address these questions and to provide insight into the problems, issues and concerns of women scientists/engineers in academe.

The Study

With the assistance of two grants from the National Science Foundation (NSF), the Evaluation and Training Institute investigated the employment and enrollment patterns of women scientists/engineers and graduate students in 8 major scientific fields defined by NSF: Engineering, Physical Sciences, Environmental Sciences, Mathematical Sciences, Agricultural and Biological Sciences, Medical Sciences, Psychology, and Social Sciences. The study consisted of two parts. The first part consisted of a series of statistical analyses of institutional and departmental patterns in women's full-time graduate enrollment and full-time employment in science and engineering in the 50 leading doctorate-granting institutions, those reporting the largest full-time scientist and engineering population on the 1976 NSF Survey of Personnel.

The second phase of the study consisted of case study site visits to a sample of 9 institutions selected to represent the

diversity of the original sample in terms of geographic location, urban/rural environment, institutional size, type of control (public/private) and proportion of women scientists employed. The case study institutions were the University of Arizona, Harvard University, Louisiana State University (Baton Rouge), University of Michigan, Northwestern University, Purdue University, University of Southern California, Texas A & M University and the University of Washington.

The principal data sources for the study were: 1) the National Science Foundation's Survey of Scientific and Engineering Personnel Employed at Universities and Colleges, collected annually from approximately 2,300 institutions (including two-year colleges) which offer degree-credit courses in the sciences and engineering; and 2) The Survey of Graduate Science Student Support and Postdoctorals, collected annually from approximately 7,800 departments in approximately 360 doctorate-granting institutions. NSF defines full-time scientists and engineers in academe broadly, to include "faculty members, postdoctorals, and other professionals (at a level at which the knowledge acquired by academic training equal to a bachelor's degree is essential in the performance of duties) working in science and engineering, including those in research administration".* All statistical analyses in this report are based on data from these surveys and include full-time employees and full-time graduate students only. Part-time employees and students are not included in the study.

*National Science Foundation, Survey of Scientific and Engineering Personnel Employed at Universities and Colleges, January, 1976. Form 724 (11-75) Instructional Sheet.

FINDINGS FROM STATISTICAL ANALYSES

The statistical analyses of the present study were designed to identify distinctive trends or patterns in the full-time enrollment and employment of women scientists/engineers relative to men. The goal of the analyses was to move beyond the presentation of numbers and percentages to search for consistent and significant differences in the institutional distributions of men and women scientists according to six variables: size of institution, geographical location, source of support, institutional orientation toward research versus teaching, and quality ranking of departments. No specific research hypotheses were formulated with regard to the effect of these variables on the enrollment and employment of women scientists. Rather, this research was exploratory and descriptive in nature.

Distribution of Women Scientists and Graduate Students

Contrary to the literature on women academics generally, women scientists/engineers employed full-time in academe are concentrated in the very largest institutions. Approximately 2,300 institutions are included in the NSF surveys of personnel. The fifty institutions drawn for the study sample from the 1976 survey population were the largest science schools -- those reporting the largest number of full-time scientists and engineering employees. These fifty schools accounted for only 2 percent of all the institutions surveyed in 1976, but they employed almost 35 percent of the full-time women scientists/engineers reported by the 2,300 institutions in that year.

Figure 1 presents the percentage distributions of scien-

tists/engineers employed full-time in the fifty-school sample along with the proportion of women in each of the eight fields. An example of the variety of disciplines included within each field is presented below and illustrates the diversity of scientific personnel included in the study.

Engineering:	All traditional engineering fields, plus architecture
Physical Sciences:	Astronomy, chemistry and physics
Environmental Sciences:	Geological sciences, oceanography, atmospheric sciences
Mathematical Sciences:	Mathematics and computer sciences
Agricultural & Biological Sciences:	Biological sciences, agricultural sciences and animal husbandry
Medical Sciences:	Medicine, psychiatry, dentistry, nursing, etc.
Psychology	
Social Sciences:	Economics, political science, sociology, linguistics, educational research

Overall, women constituted 16.4 percent of the total study employee sample. As indicated by the histogram in Figure 1, however, the proportion of women in each field varies a great deal. Women are the most prominent in psychology, where they comprise 25 percent of the employees, and least prominent in engineering, where they comprise only 3 percent of the engineering employees.

As far as graduate students are concerned, almost 24 percent of the approximately 105,000 graduate students in the study sample are women. Figure 2 presents the distribution of graduate students across the various fields along with the proportion of women in each field. As the figure indicates, the distribu-

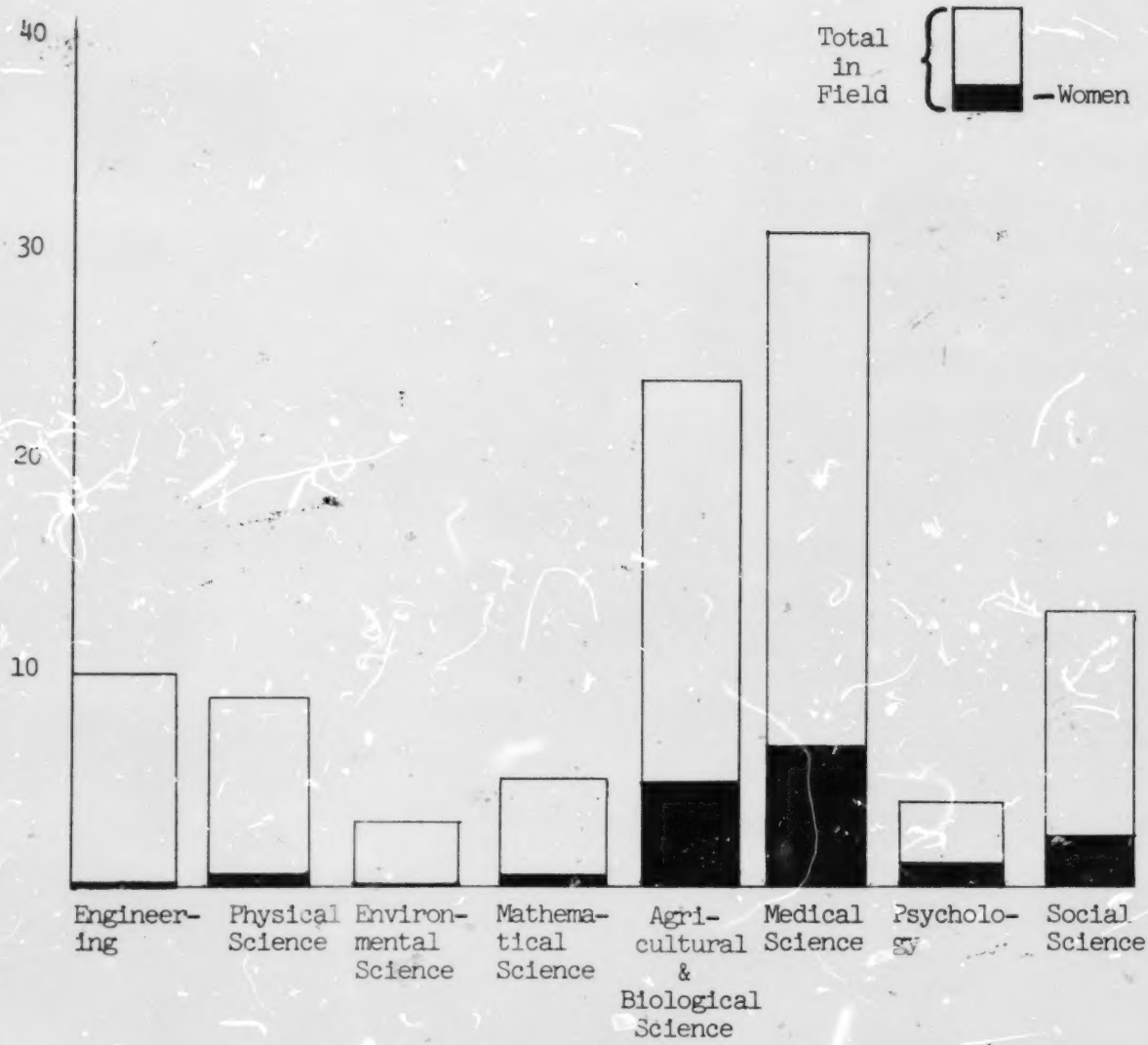

FIGURE 1. PERCENTAGE DISTRIBUTION OF FULL-TIME EMPLOYEES ACROSS SCIENCE FIELDS WITH PROPORTION OF WOMEN IN EACH FIELD, JANUARY, 1976

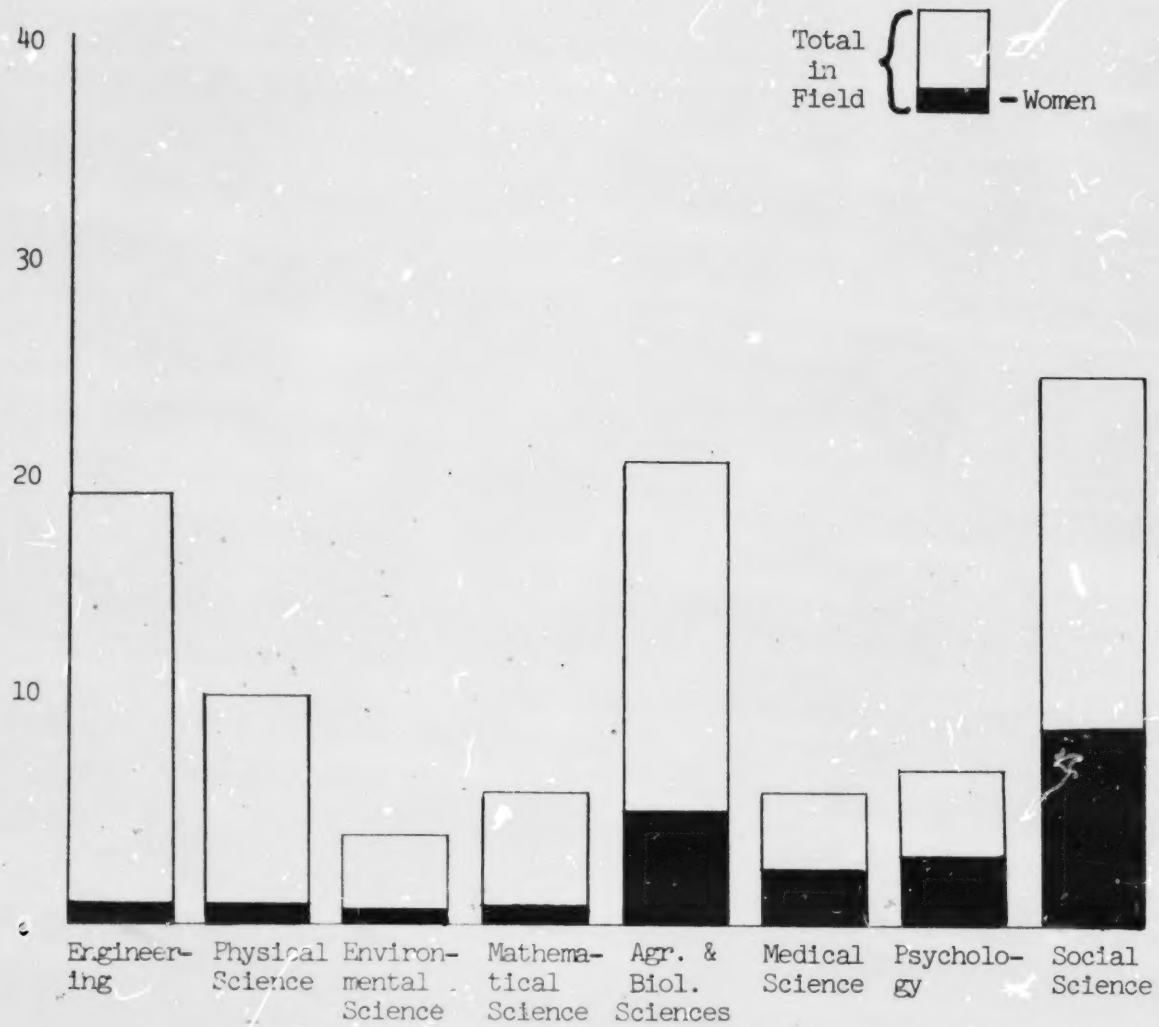

FIGURE 2. PERCENTAGE DISTRIBUTION OF GRADUATE STUDENTS ACROSS SCIENCE FIELDS WITH PROPORTION OF WOMEN IN EACH FIELD, FALL 1975

tion of women graduate students in the sciences parallels the distribution of women science employees. Graduate women are the most visible in psychology, where they constitute 45 percent of the graduate student count, and they are least visible in engineering, where only 5 percent of the graduate students are women.

The distributions of both women employees and graduate students across the various disciplines in the study sample reflect the traditional career patterns of women in the sciences. Although there have been significant increases in the number of graduate women entering the hard sciences in the past five years, women have been, and continue to be concentrated in the life sciences, the social sciences and psychology; they have been, and continue to be least visible in the more technical disciplines such as engineering and the physical sciences.

Chi Square Analyses

Chi square analyses were used as the statistical tests for the frequency distributions of men and women employees and graduate students which resulted when the data were broken down according to the six criterion variables. This statistic determines whether differences in the distributions of men compared to the distributions of women are statistically significant; whether women and men indeed exhibit distinct differences in their employment and enrollment patterns.

The significance of the computed chi square values, however, must be interpreted within the context of the percentage distributions presented along with them. The value of the chi square is dependent upon the sample size, as well as the true

differences in the distributions of the populations being compared. In some cases, the proportion of women differs only one percentage point from the proportion of men, but the computed chi square is significant because of the large sample size. In addition, because of differences in the numbers of employees or graduate students within the different fields, direct comparison of chi square values for the different disciplines is not possible.

Rather, by using the chi square test in conjunction with a careful examination of the frequency distributions, it was possible to identify general patterns and trends which characterize women's enrollment and employment in the sciences. The next sections present the results of the analyses for each criterion variable.

Institutional Size

In order to determine if institutional size and related organizational variables affected the proportion of women scientists employed or enrolled at a given school, chi square analyses were performed to determine if the percentage of women at an institution differed with the size of the institution, measured first by size of scientific and engineering employee population, and then by size of total student population. Two separate measures of institutional size were used because each measure reflects different aspects of an institution's environment. In these analyses, the proportion of women in each category of institutional size was compared to the total proportion of women in all schools combined.

The range of institutional size among the schools included in the sample was restricted, as indicated earlier, since these were the fifty schools with the largest employee counts of scientific personnel. Even within the sample, however, there was considerable variation. The employee count of scientific personnel varied from a high of 3,090 at the largest school, to a low of 735 at the smallest. Student body size ranged from a high of 58,814 to a low of 8,040.

When size of employee population is the criterion, the distribution of women science employees indicates that, as a group, women scientists are concentrated in the very largest schools. Women constitute almost 18 percent of the total employee count in schools with a scientific employee population of more than 1,650 compared to 14 percent of the total in small schools with an employee population of less than 1,250. This pattern held consistently in all but three of the eight fields: Agricultural and Biological Sciences have a greater proportion of women scientists/engineers employed in mid-sized schools, and the Social Sciences show an equal representation of women employed in small and large schools.

When institutional size is measured by student count, women scientists/engineers are found in equal proportions in large and small schools (18 percent). In medium-sized schools, their proportion drops to 14 percent. This pattern held consistently across fields, with the exception of the Mathematical Sciences where women are approximately 10 percent in both medium and large institutions and only 6 percent in small schools.

In contrast to employees, the general pattern for the dis-

tribution of women graduate students remains the same regardless of which criterion of size is used. Although slightly more prominent in mid-sized institutions, women graduate students are well-distributed across the different categories of institutional size.

The distributions for both students and employees in the agricultural and biological sciences deviate from the patterns found in other fields. When employee population is used as the criterion of institutional size, women scientists in these fields are more prominent in medium-sized institutions (22 percent), compared to large schools (19 percent) and small schools (17 percent). But when student body size is the criterion, the highest proportion of both women scientists and graduate students (30 percent each) is found in small schools.

The greatest proportion of advanced degrees awarded to women have been in the agricultural and biological sciences; in 1976, women received 23.1 percent of the doctorates in this field -- a substantial number relative to other fields.[14] Traditional female specializations within the field may account in part for the prominence of women; for example, in 1976, women received 51.1 percent of the doctorates awarded in the nutritional sciences.[15] The distribution of such programs across institutions may account, at least in part, for the discrepant patterns found in the field in this study.

Correlation between the Proportion of Women Employees and Graduate Students

In her study of sex role models, Tidball suggests that successful career women are more likely than non-career women to be graduates of undergraduate institutions with a high percentage of women faculty.[16] In order to see if women science/engineering students are more attracted to graduate programs in which more women are visible in professional roles, the data were examined to see if there was a relationship between the percentage of women employees and the percentage of women graduate students at any given institution.

The results of the correlational analysis indicated that there was no consistent relationship between the proportions of women students and employees in the eight scientific fields in the study sample. Over all fields combined, there is a moderate positive correlation of .41, but when the data are broken down by discipline, the value of the coefficients drops drastically and no consistent relationship holds. In the 50 institutions comprising the study sample, women are enrolling in science and engineering graduate programs, regardless of the numbers of women on the faculty and staff. These results do not disprove the importance of role models for women in professional training. We still do not know what degree of contact women faculty have with graduate students or the extent of their influence on post-graduate careers. The results do suggest, however, that the graduate women in this study were not completely discouraged from pursuing careers in fields where there were few professional academic women.

Geographic Region

Previous research has documented the influence of geography on the institutional distribution of academic personnel in general.[17] There appears to be a tendency for both men and women to prefer positions in the same general region of the country in which they were born, but women academics have been shown to be geographically less mobile than men.

The geographic distribution of academic science employees in this study showed slight differences in the geographic dispersion of men and women. A larger percentage of the women than the men were found in the east (27 percent vs. 25 percent, respectively) and midwest (38 percent vs. 35 percent), while more men than women were found in the south (23 percent vs. 20 percent) and west (18 percent vs. 16 percent). Within the different fields, however, the distributions of men and women scientists vary, and no consistent pattern holds.

The geographic distribution of men and women graduate students is essentially equal except for a slightly higher concentration of women than men in the east (23 percent versus 21 percent). This pattern holds in all fields except for the social sciences and the environmental sciences, and may be a reflection of the larger number of women's colleges in the eastern part of the country. These colleges draw women from all parts of the country for undergraduate work, and many of these women may well remain in the east to pursue graduate training in the sciences and engineering.

Type of Support

Public and private institutions are dependent upon different sources of financial support and are subject to different kinds of outside pressure. The resulting differences in administrative policies, including personnel policies for recruitment, promotion, retention, and salary, may have an effect on the number of women scientists/engineers employed and enrolled at an institution.

The results of a chi square test, however, indicated that there were no consistent differences in the percentages of men and women employees or students found in public or private schools. There was a slightly greater proportion of women employed in private schools compared to men (32 percent versus 31 percent, respectively), but for students, the distributions of men and women are almost identical (nearly 75 percent in public schools and 25 percent in private).

The distributions do vary, within specific fields, but there is no consistent pattern favoring either type of institution. Women mathematicians are more prominent in public schools than are men, both as students and employees; women comprise 84 percent of both mathematical science employees and students in public schools while men comprise 78 percent of the employees and 80 percent of the students. In Engineering the reverse is true, with women more prominent in private schools (27 percent of the women employees as compared to 26 percent of the men); 36 percent of the women engineering students are enrolled in private schools compared to 29 percent of the men.

While there appears to be no explicit policy operating to influence women's employment/enrollment one way or the other in either type of school, the results suggest that there may be differences in policy and curricula within specific subdisciplines which would make one type of school more appealing to women in that discipline.

Institutional Emphasis: Research versus Teaching

Being associated with an institution or department attributed with significant research accomplishments is both an important asset to and a measure of individual career development. Past research indicates that academic women have been concentrated in smaller teaching-oriented schools and are found infrequently in prominent positions in large research universities.

The schools in our study sample were the fifty leading doctorate granting institutions and research activity is primary in such schools; therefore, it is not surprising that 40 of the 50 schools were classified as research-oriented and that the greatest proportion of both men and women scientists/engineers are employed in these 40 schools. Ten of the sample schools reported on the NSF survey that teaching rather than research is the primary work activity of the majority of their science and engineering personnel, and thus these schools were classified as having a teaching emphasis.

The analysis suggests that there is still a slight tendency for a greater proportion of women than men to find employment in teaching-oriented schools (24 percent of the women as opposed to 21 percent of the men). This pattern is found in five of the

eight fields, including engineering, environmental science, agricultural and biological science, medical science and psychology.

On the other hand, women graduate students in the study sample are found in higher percentages than men in schools classified as research-oriented (83 percent vs. 81 percent, respectively). This pattern of differences, though small, is found in all fields, with the exception of engineering, the agricultural and biological sciences and psychology. Whether or not the women in our study sample who are being exposed to research training in science and engineering as graduate students will continue on in research careers in academe is, of course, open to speculation.

Prestige Level of Departments

Past research has indicated that women are not fairly represented in top-ranked institutions or departments in academe.[18] However, according to a 1973 study by Cartter and Ruhther, a larger percentage of women doctorates than men (20 percent compared to 16 percent) were being placed in the top schools.[19] Using the American Council on Education report A Rating of Graduate Programs, prepared by Kenneth Roose and C. J. Anderson,[20] these researchers divided institutions into five levels of prestige. The Roose-Anderson rankings themselves were compiled from the subjective ratings of the quality of graduate programs given by faculty and administrators in various fields. On the basis of these ratings, Roose and Anderson categorized individual graduate programs as high, medium or low quality.

To test whether women scientists in the present study were employed and enrolled in prestigious places in proportion to men, an analysis was conducted on the departmental distributions of men and women in six fields: engineering, physical sciences, agricultural and biological sciences, mathematical sciences, psychology, and social sciences. The ranking scheme of departments was developed from the Roose-Anderson report; analyses for the fields of medical science and environmental science could not be included since these fields were not rated by Roose and Anderson. Unlike the Cartter and Ruhther study, which ranked institutions, this analysis used the prestige ranking of departments, thus increasing the refinement of the ranking scheme. Although the prestige of a particular institution might not be that great, a specific department within the school might be very highly regarded. Not all schools had curricula in all fields, however, so the institutions compared vary across the different fields.

The analysis of men and women employees across science departments of varying prestige levels indicates that, in keeping with the findings of Cartter and Ruhther, and contrary to those of Ladd and Lipsett, women scientists/engineers in the study sample are being employed in the top-ranked departments in their fields. In fact, across all fields, the percentage of women scientists and engineers employed in high quality departments in our sample is greater than or equal to the percentage of men. Women in the study sample accounted for only 3 percent of the employees in engineering and 6 percent of those employed in the physical sciences. Yet, in both of these fields, the differ-

ences in the proportions of men and women in prestige departments is striking. In engineering, almost 88 percent of the women were in top-ranked departments as compared to 57 percent of the men. In the physical sciences, 65 percent of the women compared to 53 percent of the men were in top-ranked departments.

In psychology and the social sciences, women are well represented, accounting for 25 percent of the employee force in psychology and 19 percent in the social sciences. In these fields, the distribution of women across different quality departments did not differ greatly from the distribution of men. In psychology the distributions are almost identical; in the social sciences, 50 percent of the women compared to 46 percent of the men are found in the top-ranked departments. These results suggest that as the number of women increases within a discipline, their distribution across different quality schools grows more similar to the distribution of men. This trend was also apparent, though not as pronounced, in the data for graduate students.

The 50 institutions comprising the study sample are all "prestige schools", since all were listed in the Roose-Anderson rankings. A complete picture of the status of women scientists with respect to the prestige of their departments would therefore require an analysis of schools representing the full range of quality rankings. Our analyses of enrollment and employment patterns nevertheless provide an indication of relative placement within different prestige institutions, and they suggest that as the proportion of women in a field increases, sex becomes a less important variable in recruitment and promotion.

If faculty and administrators in top quality departments

have a large pool of women to evaluate along with men, they can distinguish differences in ability and productivity. The result is a similar distribution of men and women across different levels of departments, as found in the social sciences and psychology. But in a field such as engineering, where there is only a small proportion of women, highly rated departments seem to have an advantage in recruiting both graduate students and employees, as evidenced by the concentration of women engineers in the top level programs. It should also be noted that in disciplines where the pool of women is small, women tend to be outstanding in performance and ability. As more women enter a field, the population becomes more representative of all ability levels. Thus, as the number of women in this field increases, this concentration should diminish, and women engineers in academe should become more evenly distributed across the different prestige levels of programs.

Regression Analysis

In order to determine if any of the criterion variables accounted for significant differences in the proportion of women employed or enrolled at an institution, a multiple regression analysis of the five institutional variables (size of student population, size of employee population, geographic location, type of support, and activity orientation) against the percentage of women employed was performed.

The regression analysis indicated that the five criterion variables together do not account for a significant amount of the variation in the percentage of women found within the differ-

ent disciplines at a given school. In addition, none of the individual variables is a consistent predictor of the proportion of women found within a school. Although patterns do exist in the distribution of women scientific personnel with respect to size, activity orientation and geographic location, none of these variables can be identified as a significant cause of the proportion of women found in these scientific fields.

FINDINGS FROM SITE VISITS

The NSF data used in this study included women scientists who are senior faculty at prestigious research schools, as well as women with baccalaureate degrees working as assistants in university research laboratories. Women in a variety of disciplines, a variety of positions and a variety of institutions were included. Yet, despite all this diversity, according to the statistical analyses, these women scientists/engineers, as a group, exhibited certain career patterns which are very similar to women academics and women professionals in general. Statistical analyses can detect trends, and the quantitative analyses performed in this study indicated that women scientists/engineers are being employed in the top-ranked departments in the 50 leading doctorate-granting universities and colleges, a finding which implies a significant gain in status for women scientists in academe. An important variable, however, was missing. The positions that these women were occupying could not be identified through statistical analysis, and questions concerning their status remained.

During the 1977-78 academic year, we made site visits to the nine case study institutions listed previously. The case study

institutions were a representative sample of the 50 institutions that comprised the study sample. The distribution of women scientists in the various disciplines in the site visit schools matched the distribution found in the sample of 50 institutions. Women were most prominent in psychology (21.9 percent) and the agricultural and biological sciences (20.1 percent), and least well represented in engineering (2.2 percent), and the environmental sciences (4.6 percent). The range for individual school means of the percent of women employed was also similar to that found in the larger sample -- with a low of 3.2 percent to a high of 26.3 percent. The percentage of women employed within the site visit schools was 15.5 percent, slightly less than the 16.4 percent found for women in the total sample. The site visits allowed us to probe behind the statistical data in order to more fully understand the institutional and departmental processes involved in the status of women scientists/engineers.

The Status of Women Scientists/Engineers

The purpose of the NSF surveys is to monitor the supply of scientific manpower resources in the United States, a charge given to NSF by the Office of Management and Budget in 1959. The problem is that while these surveys do provide an indicator of the science manpower resources in colleges and universities, they mask the dismal reality of women scientists' positions in academe. Headcounts and simple percentages do not reveal their ranks, salaries or job status. The site visits confirmed that these numbers are grossly misleading. The absolute numbers of women scientists/engineers may be increasing in some cases, but

the percentages are small and women are still found in the lower ranks and untenured positions of academe.

We discovered that large numbers of women reported as full-time scientists/engineers on the NSF surveys, and for compliance with HEW requirements, hold off-ladder, non-tenured research scientist appointments, most often funded by extramural grants rather than general University funds. Many of these women have to find their own grants in order to receive a salary. For a few women, a research position was a voluntary and satisfactory choice, but for many it was a forced and unwelcome compromise. Many married doctorates were unable to obtain regular faculty positions because of institutional nepotism customs which, in practice, discriminate against women. Other women had received their doctorates at the institution where their husbands were employed, subsequently finding themselves ineligible for faculty ladder positions because of the "we never hire our own" policy. Like nepotism practices, this policy protects an institution from losing its vitality and becoming sterile through inbreeding. Inherently not discriminating, in practice it severely discriminates against women, and the consequences are exceptionally severe when the university is an isolated area with limited or no alternatives for employment at other postsecondary institutions or in industry.

While research scientist positions can be valuable experiences for women who are beginning their professional careers, these positions do not carry the prestige, high status or salary of regular faculty appointments. Along with other "adjunct" or "acting" positions, research scientists are for the most part a

disenfranchised, second-class faculty whose grant moneys contribute overhead to the institution. Denied the right to vote or even attend faculty meetings, they are responsible for serving on committees, teaching courses and supervising doctoral students. Most significantly, these positions hinder professional development if they are held for a long period of time. Rarely are tenured faculty appointments made from among an institution's lecturers or research scientists, and seldom are these people recruited by other universities, particularly if they have held this type of appointment for more than a few years.

Unfortunately, the prospects for a dramatic change in the status of women scientists in the near future are slight, despite the increasing numbers of women entering scientific fields. Women are entering the system and coming up for promotion just as retrenchment and tight budgets are reducing the number of faculty positions and tenure slots. The development of new programs has been curtailed and many programs have been cut back or eliminated. As a result, few departments are expanding. In some instances, and this seems to be particularly true in the natural sciences and mathematics, there is a heavy concentration of older, tenured faculty, and only rarely does more than one position open up in a four to five-year period.

Instead of hiring new Ph.D.s on tenure tracks, more and more colleges are turning to limited-term, contract appointments to bring in new blood and maintain departmental vitality. The term of appointment varies. Some institutions merely expand the one-year visiting professor plan as needed. In most insti-

tutions, the rotation cycle is three years; in a few, it is six years. In all cases, the positions are terminated and there is little or no chance of being retained on a permanent faculty status. Even worse, this practice creates a double bind. As one woman explained, her six-year position was terminating and there was no chance that she would be retained. She had applied for several positions at other institutions only to be told that she was "too old professionally". Those institutions, too, were looking for new or recent Ph.D.s to put on short-term appointments. Again, although this practice is not inherently discriminatory and applies equally to male as well as female appointments, the consequences are that it severely limits the advancement of women in the academic world at a time when they are being encouraged to enter it.

In spite of the conditions of employment, however, we did find the atmosphere to be noticeably different at institutions which had a relatively high percentage of women scientists. Department chairmen* at institutions with few women were quick to describe their recruiting procedures as a search for "the best qualified candidate". "We'd love to hire a qualified woman, but we won't beat the bushes to look for her" was a frequent statement. But at institutions where there were comparatively more women scientists, deans and department chairmen added to the "best qualified" statement a consideration of women's more limited opportunities heretofore. These deans and department chairmen created an atmosphere of intention and action, using whatever

*The term chairmen is used purposefully, since all of those we met were men.

means of affirmative actions necessary, in the truest sense of the words, even if these means were non-traditional.

This spirit was reflected in departments which, if necessary, will hire their own graduates in order to bring women into the field. It was reflected in the special courses established to help young women learn how to use basic tools that are usually part of a boy's life. It was reflected in the special counseling courses designed to increase the retention of women in engineering. The presence of more women scientists at an institution was found to be related to the presence of more women faculty generally; an active Society for Women Engineers on campus; a good job market in the area; and, most important, an active outreach program and publicity regarding the opportunities for women in science.

The relationship between the number of women in regular tenured positions in a school/department and the attitudes and intentions of the dean/department chair will become even greater in the near future. Department chairs can shift their needs to meet the qualifications of available women applicants or remain inflexible. In one large case study institution, the dean and several department chairs spoke of their willingness to "mortgage" an upcoming retirement slot if they found a woman who was well qualified in an area other than the one for which they were recruiting. In this way, they could meet the department's needs and still hire a qualified woman. Without affirmative action policies, it is doubtful that such social awareness and consciousness would have worked in quite this way.

Statistics are used by the courts both as a measure of dis-

crimination and as a measure of compliance. When the evidence indicates that there has been a pattern of discrimination, the burden of proof is shifted to the employer, who must demonstrate that there is and has been no discrimination, that the job criteria are genuinely related to the job, and that employment practices and policies do not have and have not had a discriminatory effect. Departments cannot deny charges of discrimination on the basis that no women apply. Underutilization raises a presumption of discrimination under Executive Order 11246 and Title VII on the assumption that an institution's reputation for being discriminatory may have discouraged qualified women from applying for positions in the first place.

Our impression from the site visits is that affirmative action is working, but to a limited degree. Women scientists/engineers are being allowed entrance to academe. In the case study institutions, women academics generally were receiving a somewhat larger share of the new hires because of affirmative action. But the door is rotating and they exit almost immediately, as most of these new positions are short-term and the chances of becoming part of the tenured faculty are slim.

Institutional researchers, university administrators, department chairs and federal policy-makers should consider focusing less on the numbers of women scientists employed or the numbers of women graduate students enrolled and more on who and where in the system these people are. Otherwise, the status of women in academe will not change.

Graduate Women and Their Future in Academe

There are many myths and a great deal of conjecture in the literature regarding the status and attitudes of graduate women. Academe has traditionally been a male domain and stereotypic biases and prejudices no doubt remain, particularly in male-dominated departments. But among the graduate women we met, only a small minority had experienced discriminatory acts. Admittedly, we met only the successful ones -- those enrolled in and apparently satisfied with their programs, but we found no evidence to confirm the tales of rampant discrimination emphasized in the literature. By and large, the almost 400 graduate women we interviewed were extremely satisfied with their graduate education.

Most of these women agreed that there were male faculty who were disinterested in them or their projects presumably because they were female. But there were just as many, if not more, they said, who were supportive and went out of their way to help and encourage them. This was generally true also of women scientists on the faculty. Several felt that when they were graduate students, their chairman or their advisor had gone out of his way to encourage and support them. These women perceived discrimination as isolated incidents -- acts of old-fashioned or unpleasant individuals, whose prejudices against women were clearly their problems, and this had not touched them or interfered with their goals. Some of the "discriminatory" male faculty were just as routinely complained about by male students, and some women faculty were also mentioned as being unsupportive.

The women to whom we spoke were pursuing degrees in a variety of non-traditional areas -- oceanography, marine biology, marine science, fisheries, geosciences, mineral economics, spider ecology, geotechnics, watershed management and mine engineering. But in order to increase the potential pool of women scientists/engineers who are qualified for academe, the number of women receiving Ph.D.s in these fields must increase. Yet, the goal for the majority of the women, as well as the men graduates we met, was a master's degree and not a Ph.D.

Many women were enrolled in doctoral programs because there was no master's program available in that field or because stipends were only available for doctoral students. Other women were leaving with a master's degree to get married.

Above all, the opportunities offered by private industry are the major reason few women continue graduate training and complete their Ph.D.s. Industry is making better offers in terms of salary and opportunity, and the offers are for master's and bachelor's degrees, not doctorates. We were told over and over again, at all the site visit institutions, that "industry is skimming our most talented women off at the master's and bachelor's level". In the geosciences, one professor told us that industry was hiring at the rate of 30 master's degree candidates to one doctorate. Instead of broadening their areas of expertise, Ph.D.s in many fields narrow their area of expertise and reduce their employment opportunities.

The recruitment efforts of private industry are now, and could well continue to be a significant source of competition to

colleges and universities trying to meet affirmative action goals. Disciplines like engineering, geology, geosciences and environmental and biological sciences place the vast majority of their graduates in private industry and they are thus hardly likely to increase the pool of women scientists qualified for academic positions. Whether or not women who take these positions are promoted and advanced once in industry remains to be seen, and should be investigated, but nevertheless these women cannot be included in the resource pool for academe.

Industry is clearly courting women and is able to offer them excellent salaries and positions for less rigorous training than that required by academe. It also provides them with excellent opportunities to concentrate on their research undeterred by teaching responsibilities or publishing pressures. Contrary to the literature which suggests that women prefer teaching to research, the graduate women we interviewed and heard about, as a rule, preferred research to teaching. Private industry offers them this opportunity.

Academe, on the other hand, has little to offer: positions are few, salaries are poor, the training for a Ph.D. is long, and few institutions today can offer inviting prospects for a secure future. Many of the women enrolled in the doctoral programs who declared a definite interest in academe were foreign women who came to this country to earn their degree, and they were planning to return home once it was completed. For the majority of other women, jobs in industry and federal laboratories were far more attractive, and these jobs were more plentiful at both the bachelor's and master's levels.

Future career patterns for women in scientific fields, however, cannot be easily predicted. Although more women today than in previous years are receiving graduate training in scientific disciplines, the pipeline has not been in place long enough to track the careers of younger women scientists in either academe or private industry. Yet there are policies which can be implemented now to further develop the potential of women in science, and to increase their status in the academic environment.

POLICY IMPLICATIONS AND RECOMMENDATIONS

The human rights movement of the sixties expanded women's awareness of the alternative roles available to them, and the increasing numbers of women that have pursued graduate education in the sciences in recent years have no doubt been influenced by the spirit of these times. This study leads us to conclude, however, that making promised opportunities a reality for women in the sciences will require both time and concerted effort on the part of institutional administrators, government policy-makers, and women scientists themselves. Women are still a small minority in the scientific community, without much power or prestige. To a great extent, their position is the result of economic forces and cannot be attributed to overt discrimination on the part of individuals or institutions. Yet, certain administrative policies and a simple lack of awareness on the part of many male faculty and administrators have also served to limit women's advancement.

Based on the findings of this study, we believe that women scientists in academe are in a period of transition. Since the

beginning of the 1970's, more women have enrolled in graduate programs in science and engineering than at any time in the past. It is too early to assess the impact that the larger population of women scientists/engineers will have upon the status of women in the scientific community generally and in academe specifically. However, if women want a role in determining the future course of the scientific enterprise in our society, they must be willing to accept the challenge and persist in their training and careers.

At the same time, there are several policies and procedures suggested by the findings of this study which could be adopted by NSF, other federal agencies, professional scientific organizations, and the universities and colleges to facilitate the entry and advancement of women into the scientific community. We wish to emphasize that these recommendations are not intended to comprise a complete or comprehensive program with respect to women scientists/engineers in academe. Rather, these recommendations reflect specific suggestions evolving from the site visit discussions and our review and analysis of existing data sources on women scientists/engineers in academe.

Data Collection:

Additional data needs to be collected at the national level on the job positions, length of service, salaries, and work activities of women scientists/engineers in all employment sectors to allow researchers to more accurately assess their career development.

If NSF wishes to monitor the status of women scientists/engineers, we suggest that questions regarding their employment status be integrated into the surveys of scientific and engineering personnel and graduate enrollment, or new surveys highlighting the enrollment and employment patterns of women scientists/engineers could be developed.

NSF currently collects such data on women doctoral scientists/engineers through the Survey of Doctoral Scientists and Engineers. Based on the findings of this study, we believe such data needs to be collected for women at all degree levels who are employed in science and engineering fields in academe.

Private Industry

Data on the employment status and career patterns of women scientists/engineers employed in the private sector also needs to be collected, since as found during the course of this study, a large number of women scientists/engineers are being attracted into private industry. To date, there are no comprehensive studies of the employment of women scientists/engineers in the private sector.

We suggest that NSF fund a companion study to the present study to explore the employment status of women in private industry, and to make recommendations for collecting data on the employment status and career patterns of women entering private industry.

Fellowship and Research Programs:

During the site visits, we heard several suggestions for the allocation of fellowship and grant monies, including the suggestion that NSF award each institution a specific sum reserved for women scientists/engineers who wish to conduct research, so that all institutions have an opportunity to attract qualified women. Some objected to this policy, saying that NSF should award the money directly to the individual, thereby giving women scientists the flexibility to choose the institution with the best resources for their particular research project.

In order to determine which policy would be more effective in promoting research activity among women, we suggest that NSF fund a study making a comparative analysis of alternative methods of awarding fellowship and research money to women scientists and engineers. Site visits to a sample of diverse institutions where women are engaged in research should be required as part of the study design.

Directories and Registers of Women Scientists/ Engineers:

During the site visits, we found that many administrators and members of faculty search committees did not know how to locate qualified women for job openings. For example, the registry of women scientists compiled by the Association of Women in Science was generally not known, and several of the people we interviewed noted the name of this resource when we mentioned it.

We suggest that NSF consider sponsoring the compilation of a comprehensive list of available directories and registers published by professional scientific organizations to be sent to all science and engineering departments in the 100 leading institutional employers of science and engineering personnel. This could be accomplished through a small grant.

Regardless of what policies or programs are implemented by NSF or any other agency to attract women into scientific fields, women must take responsibility for moving into prestige positions in the scientific community. As Goldman and Hewitt have observed, any group that is poorly represented in the scientific community is partly disenfranchised with respect to directing the future course of American society.[20] Women scientists and engineers must continue to pursue careers in academe as well as in private industry, so they can contribute equally to the education and training of the future generations of scientists. But academe, as well as private industry, must provide them the opportunity to do so.

REFERENCES

[1] The Chronicle of Higher Education, v. xv (17), January 9, 1978. Source: U.S. Census Bureau and National Center for Education Statistics, U.S. Department of Health, Education and Welfare.

[2] Project on the Status and Education of Women. Trends in Female Degree Recipients, Fact Sheet, March, 1977. Reprinted from: Eiden, L. J. Trends in Female Degree Recipients, American Education, v. 12 (9), November, 1976. Source: National Center for Education Statistics, U.S. Department of Health, Education and Welfare.

[3] Summary Report 1976: Doctorate Recipients from United States Universities, National Research Council, National Academy of Sciences, March, 1977, p. 4. See also Summary Reports 1975, 1974 and 1973.

[4] National Science Board. Science Indicators, 1976. Report of the National Science Board and National Science Foundation, Washington, D.C.: U.S. Government Printing Office, p. 154.

[5] Scientific Manpower Commission. Professional Women and Minorities: A Manpower Data Review Service. Table A-WF-3A "Women as Percent of All Faculty, 1972-73 and 1975-76". Source: National Center for Education Statistics.

[6] National Science Foundation. Manpower Resources for Scientific Activities at Universities and Colleges, January, 1977. Detailed Statistical Tables Appendix B (NSF 77-321). Survey of Science Resources Series, Table B-7. "Full-time Scientists and Engineers Employed in Universities and Colleges, by Field and Sex: January, 1974-77", p. 4.

[7] Ladd, M. and Lipsett, S. Faculty Women: Little Gain in Status. Chronicle of Higher Education, September 24, 1975.

[8] Scientific Manpower Commission. Professional Women and Minorities: A Manpower Data Resource Service. Table A-WF-4B, "Women as Percentage of Faculty Members in Four-Year Colleges and Universities, by Rank, 1959-60 to 1974-75". Source: National Education Association data and National Center for Education Statistics.

[9] Chronicle of Higher Education, v. xvi (11), May 8, 1978. Source: Untitled Study by Dr. Gloria C. Hewitt, University of Montana.

[10] Chronicle of Higher Education, v. xvi (11), May 8, 1978 Source: American Chemical Society.

[11] Scientific Manpower Commission. Salaries of Scientists, Engineers and Technicians, October, 1977. Table 122: "Mean Salaries of Full-time Instructional Faculty in Higher Education by Academic Rank, Length of Contract and Sex", 1974-75 and 1975-76.
Source: National Center for Education Statistics, Salaries, Tenure, and Fringe Benefits of Full-time Instructional Faculty in Institutions of Higher Education, 1975-76.

[12] Scientific Manpower Commission. Salaries of Scientists, Engineers and Technicians, October, 1977. Table 121: "Mean Faculty Salaries by Type of Institution, Rank and Sex", 1976-77.
Source: Preliminary data, National Center for Education Statistics.

[13a] Scientific Manpower Commission. Salaries of Scientists, Engineers and Technicians, October, 1977. Table 53: "Median Annual Salaries of Chemists by Type of Employer, Degree Level and Sex", 1977.
Source: American Chemical Society, 1977 Report of Chemists' Salaries and Employment Status, June, 1977.

[13b] Scientific Manpower Commission. Salaries of Scientists, Engineers and Technicians, October, 1977. Table 54: "Median Annual Salaries of Chemists by Work Activity, Degree Level and Sex", 1977.
Source: Chemical and Engineering News, v. 55, June 20, 1977, p. 33.

[13c] Scientific Manpower Commission. Salaries of Scientists, Engineers and Technicians, October, 1977. Table 62: "Median Salaries of Chemists by Degree Level, Sex and Years of Experience", 1977.
Source: American Chemical Society, 1977 Report of Chemists' Salaries and Employment Status, June, 1977.

[14] Professional Women and Minorities: A Manpower Data Resource Service, op. cit., Table LS-B-1, "Degrees Awarded, by Sex and Level of Department".
Source: U.S. Office of Education.

[15] Ibid., Table LS-B-3, "Doctorates Awarded from 1920 to 1976 by Subfield of Doctorate and Sex".
Source: National Research Council.

[16] Elizabeth Tidball and V. Kistiakowsky, "Baccalaureate Origins of American Scientists and Scholars", Science, v. 193, August, 1976, pp. 646-52.

[17] J. Bernard, Academic Women (University Park: Pennsylvania State University Press), 1964, pp. 91-93.

[18] Carnegie Commission, op. cit., pp. 109-115.

[19] Alan M. Cartter and W. Ruhther, "Disappearance of Sex Discrimination in the First Job Placement of New Ph.D.s", ERIC Publication (ED 104255), 1975, p. 28.

[20] K. D. Roose and C. J. Andersen, A Rating of Graduate Programs, Washington: American Council on Education, 1970.

[21] R. D. Goldman and B. N. Hewitt, "The Scholastic Aptitude Test Explains College Men Major in Science More Often than Women", Journal of Counseling Psychology, v. 23 (1), January, 1976.

PUBLICATIONS AND PRESENTATIONS BASED ON THE STUDY OF WOMEN SCIENTISTS/ENGINEERS

Rose, Clare and Nyre, Glenn F.
A Holistic Approach to Evaluating Affirmative Action Programs for Women Scientists and Engineers. Paper presented at the annual meeting of the American Educational Research Association, Toronto, Canada, March, 1978.

Rose, Clare, Nyre, Glenn F., Menninger, Sally Ann and Foster, Penny
Responsiveness vs. Resources: The Implementation and Impact of Affirmative Action Programs for Women Scientists in Postsecondary Education. Paper presented at the Association of Institutional Research Annual Forum, Houston, May 21-26, 1978.

Rose, Clare and Menninger, Sally Ann
The Future of Women in Science and Engineering. Keynote address at Women's Career Day in Computer Science at the University of Southern California, October 7, 1978.

Menninger, Sally Ann and Rose, Clare
Women Scientists in Academe: The Numbers and What the Numbers Don't Say. Paper presented at Fourth Annual Conference on Women in Education sponsored by the American Educational Research Association, Madison, Wisconsin, October 28, 1978.

Rose, Clare and Menninger, Sally Ann.
Women in the Computer Sciences.

Menninger, Sally Ann and Rose, Clare
Women in Engineering: Living a New Career Option. Paper presented at American Educational Research Association annual conference, San Francisco, April 8-12, 1979.